Space Weather Technical Forecast

Issued on Sunday, 21 May 2023 at 13:11 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: R1/R2 radio blackouts expected throughout with a chance of High activity. Chance of G1/Minor Geomagnetic Storms between 21 and 23 May.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been High over the last 24 hours, with a peak flare of M8.9 at 20/1235UTC from AR3311, a complex region in the northeast quadrant, which contains a delta spot. This region has produced five M-class flares in total and was responsible for much of the solar activity. AR3312, a region on the southeast limb has also shown developments, but remains as a beta region. AR3305 has a history of flare activity, but has been relatively inactive. AR3310 has not produced any flare activity, but has developed into a beta region. The remaining regions are either weak or only developing slowly.

A CME seen in imagery lifting off the southeast quadrant early on May 21 is currently under going analysis for any potential Earth-directed component. Otherwise, no Earth-directed CMEs have been observed in the past 24 hours.

Solar Wind / Geomagnetic Activity: The solar wind, as measured at L1 has been indicative of a CIR (co-rotating interaction region and possible high speed stream connection, perhaps from coronal hole 03. Solar wind speeds have ranged between 430km/s to 630km/s, with a slow declining trend. Density started the period around average, but declined to below average. Total magnetic field strength started the period Moderate at around 16nT, but has weakened, currently around 4nT. The north-south component, Bz, has been mostly at neutral levels. Phi angle was negative (towards the Sun). As a result of the above solar wind parameters, geomagnetic activity has been mostly Quiet to Unsettled (Kp1-3) in the past 24 hours.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV), as measured at GOES16 has remained at background levels throughout.

High energy electron flux (greater than 2MeV), as measured at GOES16 was at background levels. The 24-hour integrated fluence has been well below Active levels. At 21/0001UTC, 2.16e6 integrated pfu was recorded.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be mainly Moderate, with a chance of High activity, due to either multiple M-class flares, or a chance of X-class flares. The main risk region is AR3311 in the northeast quadrant, which has produced multiple M-class flares and continues to develop in complexity. Other regions in the southeast and northwest also present a heightened flare risk.

Solar Wind / Geomagnetic Activity: A CME which left the Sun on 17 May, may glance the Earth on Day 1 (21 May), but with relatively low confidence. A CME seen in imagery lifting off the southeast quadrant early on May 21 is currently under analysis for any potential Earth-directed component.

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Solar winds from coronal hole 03 are expected to decline later on 21 May, but perhaps will not reach ambient levels. An increase is then possible either later on Day 2 (22 May) or more likely on Day 3 (23 May), due to a high speed stream from coronal hole 06 with speeds of 500-600km/s possible.

Geomagnetic activity is expected to start Quiet to Unsettled on Day 1 (21 May), becoming Unsettled to Active due to the possible effects of a glancing CME, with a slight chance of a G1/Minor Storm. Further effects are possible during Days 2 and 3 (22 and 23 May) due to the residual CME effects and the connection to a coronal hole high speed stream.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux carries a daily slight chance of S1, largely as a result of the eastern hemisphere spots, with this very gradually rising over the four days.

High energy electron flux (greater than 2MeV) will most likely remain at background levels throughout, with electron fluence remaining below the Active (1e8 integrated pfu) threshold.

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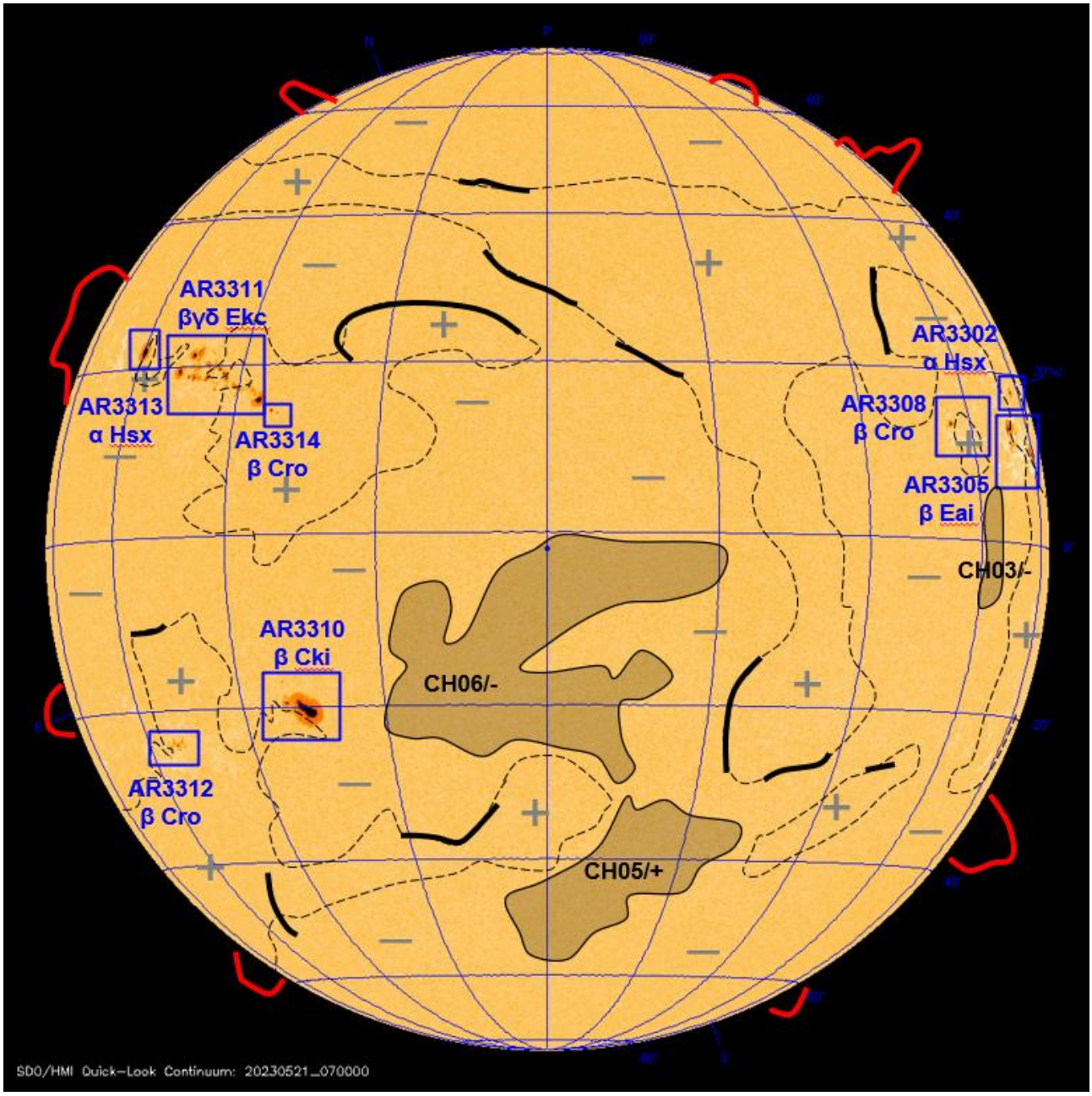
Figure 1. Solar Analysis Valid 21/0700 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

One CME is forecast to affect the Earth during the forecast period. This feature left the Sun on 17 May and is forecast to glance the Earth on 21 May, as suggested by the Enlil ensemble forecast, from around 21/1200UTC. A large coronal hole (CH06/-) in centre disc, presents a risk of increased activity, with speeds of 500-600km/s possible from either Day 2 or most likely Day 3 (22-23 May).

Geomagnetic activity is forecast to be mainly Quiet to Unsettled at first on 21 May, increasing to Unsettled or Active, with a risk of G1/Minor storms due to the possible glancing CME arrival. Residual geomagnetic storms are then possible through in 22 May, due to a potential combination of CME and coronal hole enhancements. Any enhancements may then continue into 23 May due to the coronal hole effects, with a reduction in activity on 24 May.

Geo-Magnetic Storm / Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	**G1 to G2**	No	20	30	30	10
Strong	**G3**	No	1	10	10	1
Severe	**G4**	No	1	1	1	1
Extreme	**G5**	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
18/0316	Partial	Filament eruption	SW	400 km/s	21/1200 UTC	Possible glancing blow

Figure 2: MOSWOC Enlil (top) and ensemble (below) models show possible glancing blow on 21 May. Wide spread of ensemble members shows possible arrival times during the UTC day.

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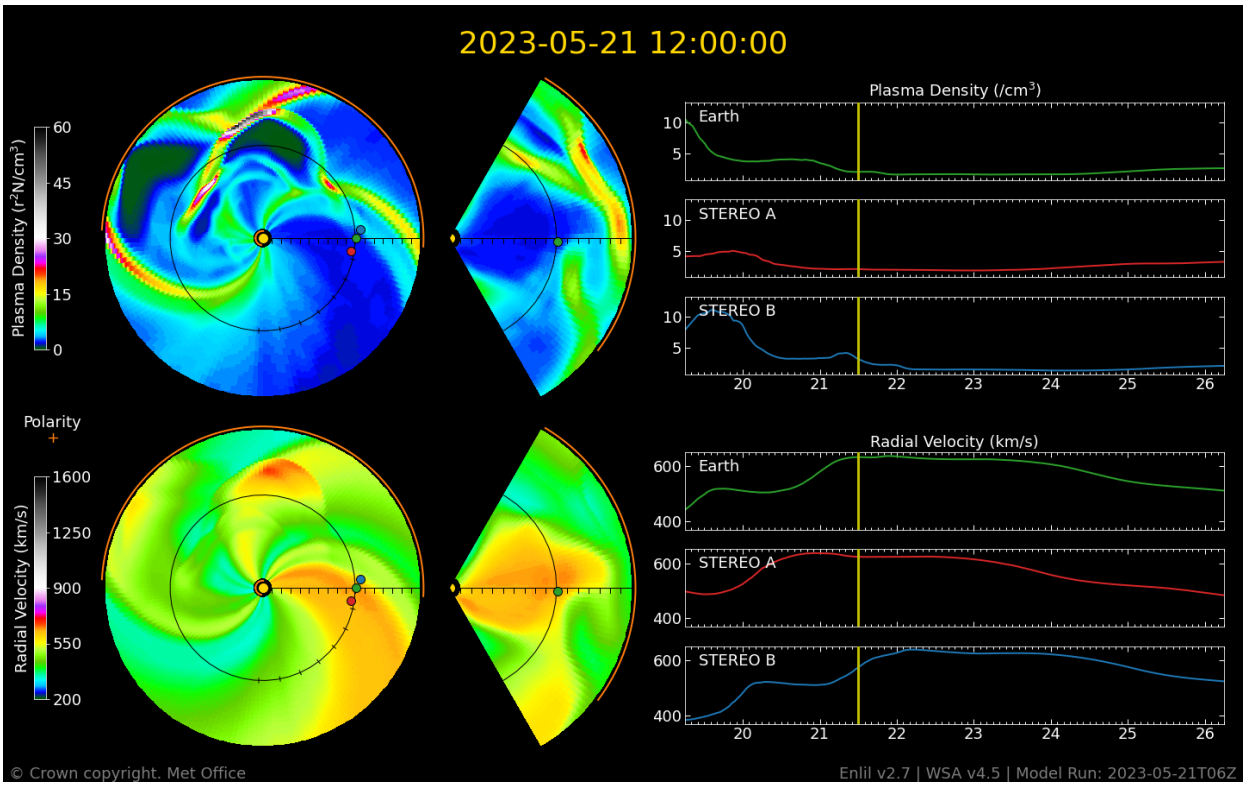

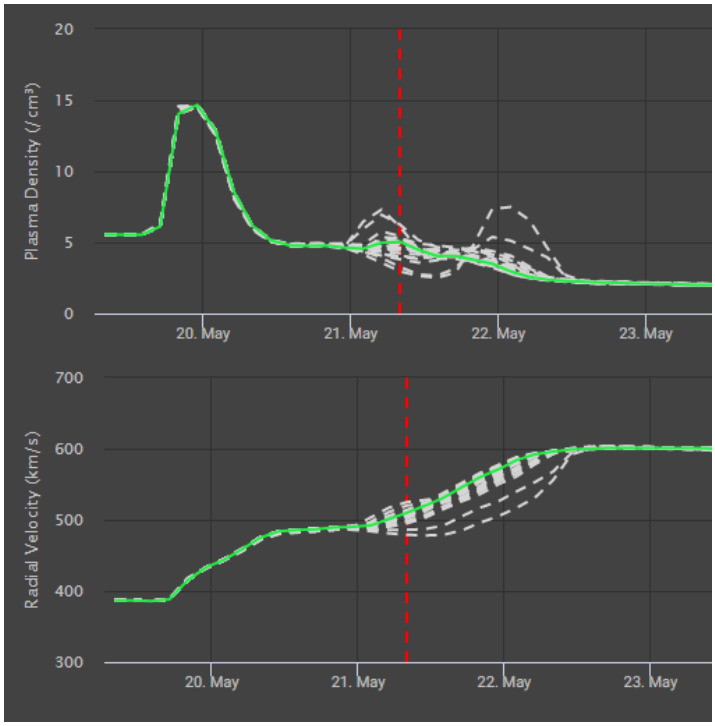

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Radio Blackouts - X-Ray Flares:
AR3311, a large and complex region in the northeast quadrant has developed two small but distinct delta spots within the last 24 hours, with a significant increase in activity. However, one of those delta spot has since faded, although further developments are likely within this complex region.

AR3305 appears to be declining, but is difficult to analyse due to foreshortening as it is close to the western limb. AR3112, close to the southeast limb appears to be relatively simple, but has produced an M-class flare and is starting to develop further complexity. AR3310 has developed bipolar characteristics and needs monitoring for further developments. The remaining regions are all relatively benign or only evolving slowly.

Solar activity is expected to be mainly Moderate to High, with a risk of X-class flares, especially from AR3311 in the northeast quadrant. There is a slight decrease in risk from 24 May as AR3305 rotates across the western limb.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	Yes	70	70	70	60
Very Active	R3 to R5 X Class	No	20	20	20	10

Figure 3: AR3311 in the northeast is largest and most magnetically complex, with delta spot contained within its intermediate spots. This region has produced numerous M-class flares in the past 24 hours (see GOES X-ray flux).

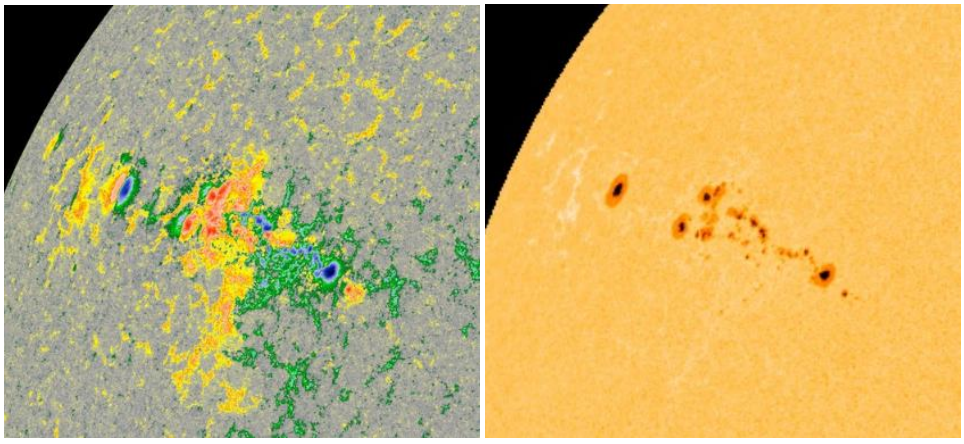

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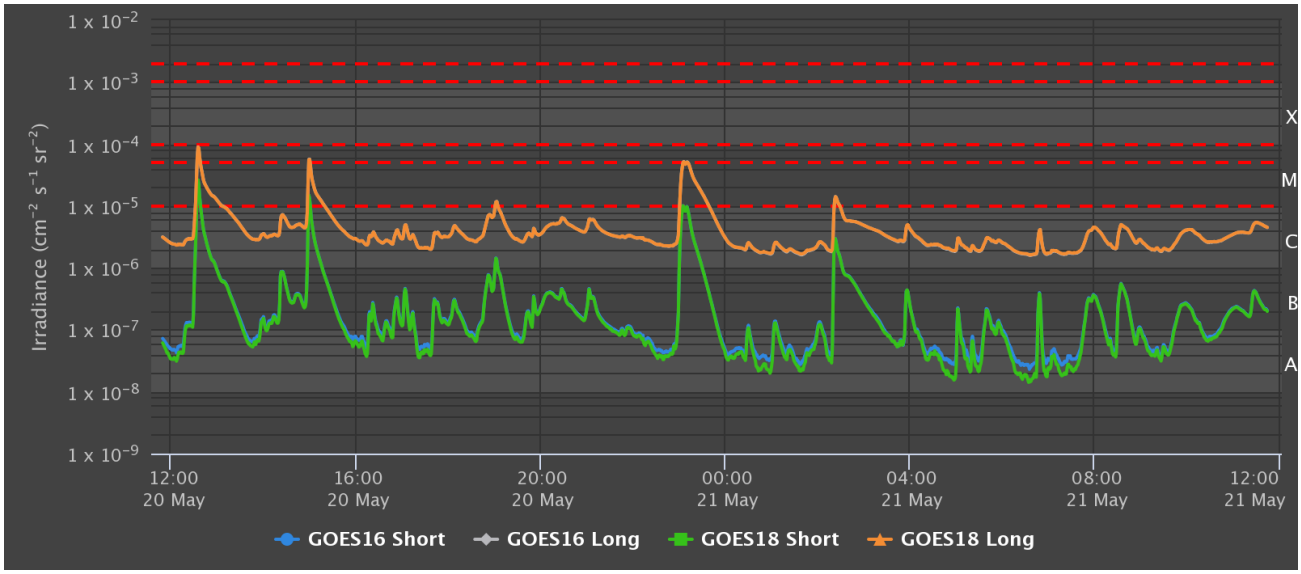
Figure 4: GOES X-ray flux – shows five M-class flares originating from AR3311 in the northeast during the past 24 hours.



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Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux, as observed by GOES16 has remained at background levels throughout and is expected to remain as such throughout the period.
AR3311 is currently the most likely source for any further enhancements, and to a lesser extent AR3305. The risk of high energy proton events is therefore not negligible, and increases slightly through the period as AR3311 moves into the western hemisphere.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	10	15	15
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

The high energy electron flux (greater than 2MeV) has remained at mainly background levels through the last 24 hours, as the strengthening of the high speed stream which would normally input electrons into the belts, is balanced by the increased geomagnetic activity which has helped to redistribute electrons. The strength of the solar wind will also help to have distorted the radiation belts from their natural orbits.

Over the next four days, there is high uncertainty in the behaviour of electron flux and consequent fluence. This is again due to the uncertainty in the possible connection with the high speed stream from coronal hole 06 and the decrease in speed from coronal hole 03.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	5	5
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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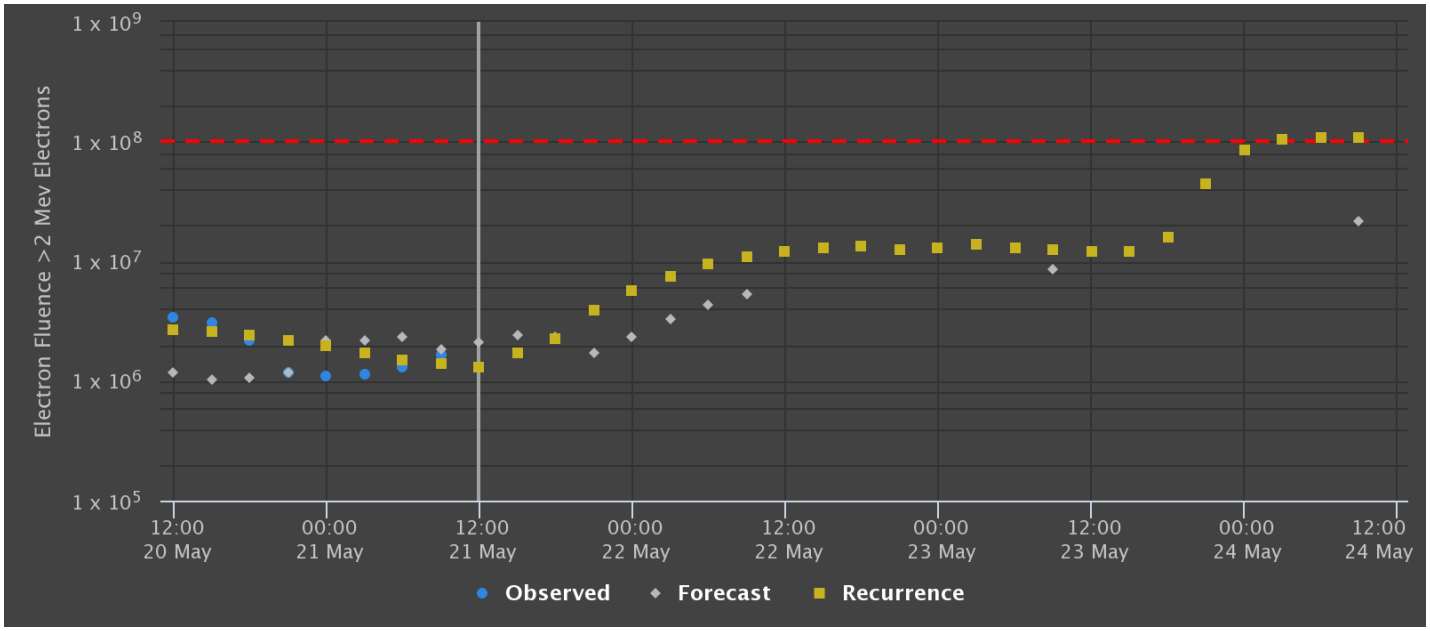
Figure 5: MOSWOC REFM electron fluence – possible rising trend towards the end of the 4 day forecast period.



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